Lecture Module - Frequency Filters

ME3023 - Measurements in Mechanical Systems

Mechanical Engineering

Tennessee Technological University

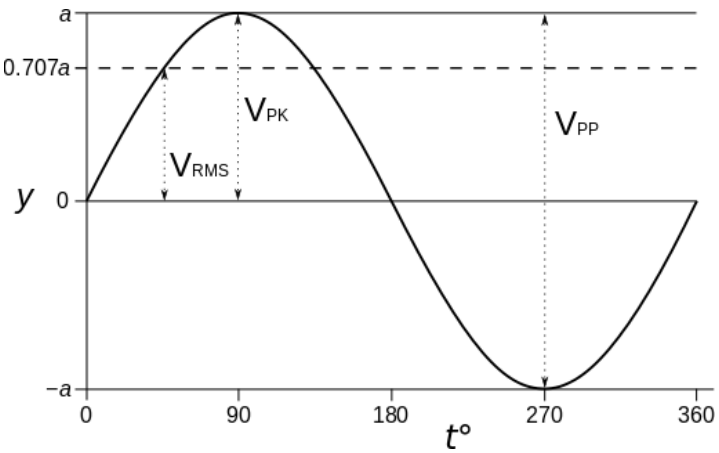
Topic 1 - What is a Frequency Filter

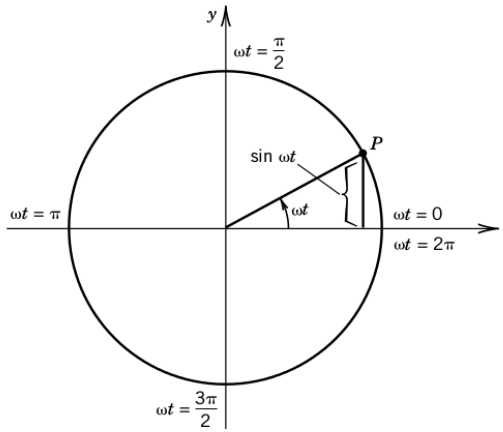
Topic 1 - What is a Frequency Filter

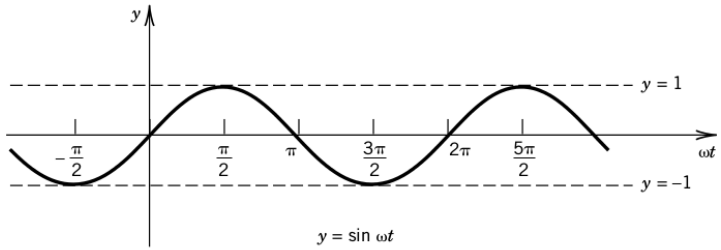
- Signal, Amplitude, and Frequency
- Filter Concept
- High-Pass, Low-Pass, and Band-Pass
- Applications
- MATLAB Activity

Signal, Amplitude, and Frequency

Signal, Amplitude, and Frequency



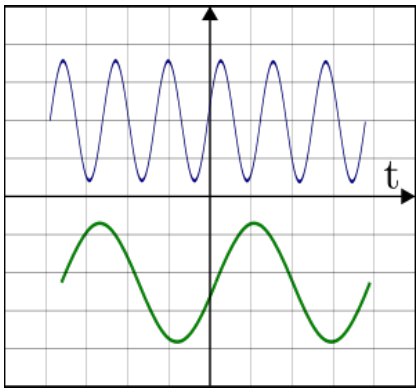


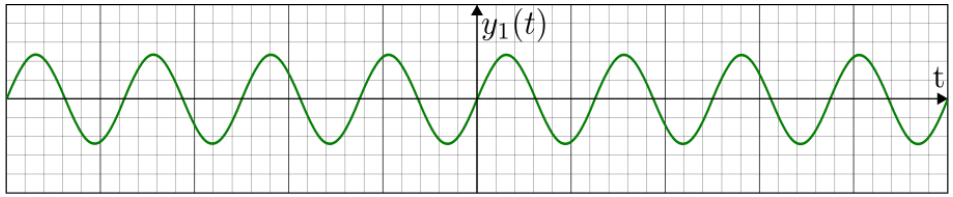


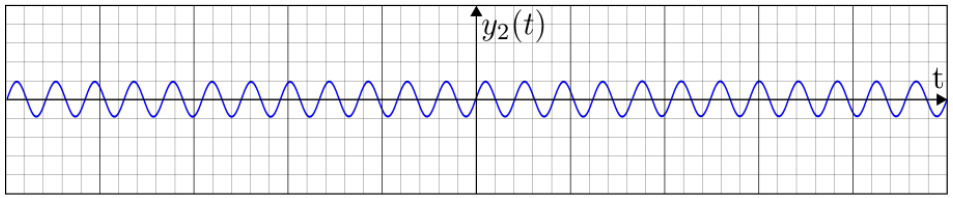
What is the relationship between the unit circle and frequency?

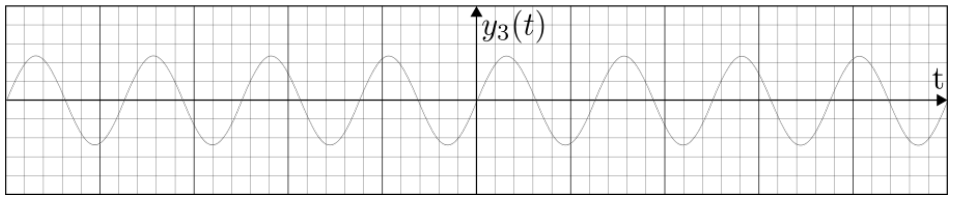
Signal, Amplitude, and Frequency

Signals can be composed of multiple *frequency components*. (see Fourier Analysis Ch2).

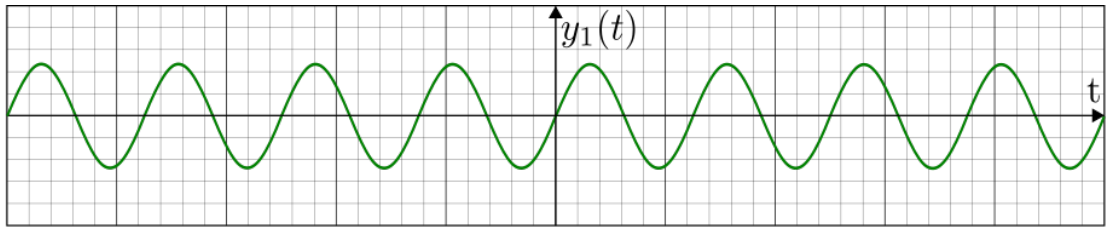


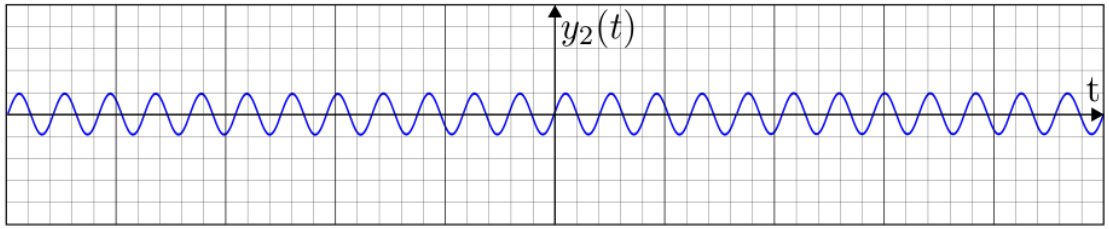


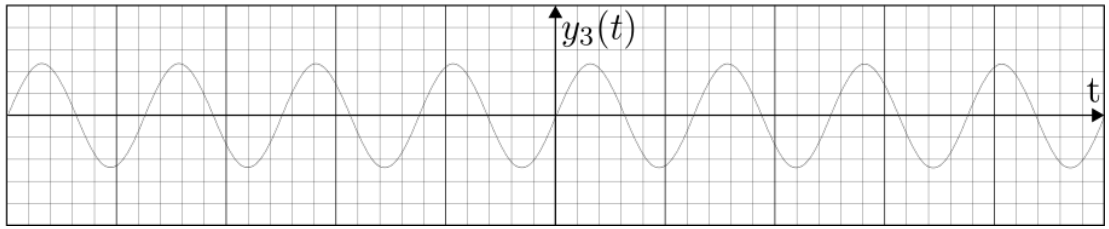




Signal, Amplitude, and Frequency

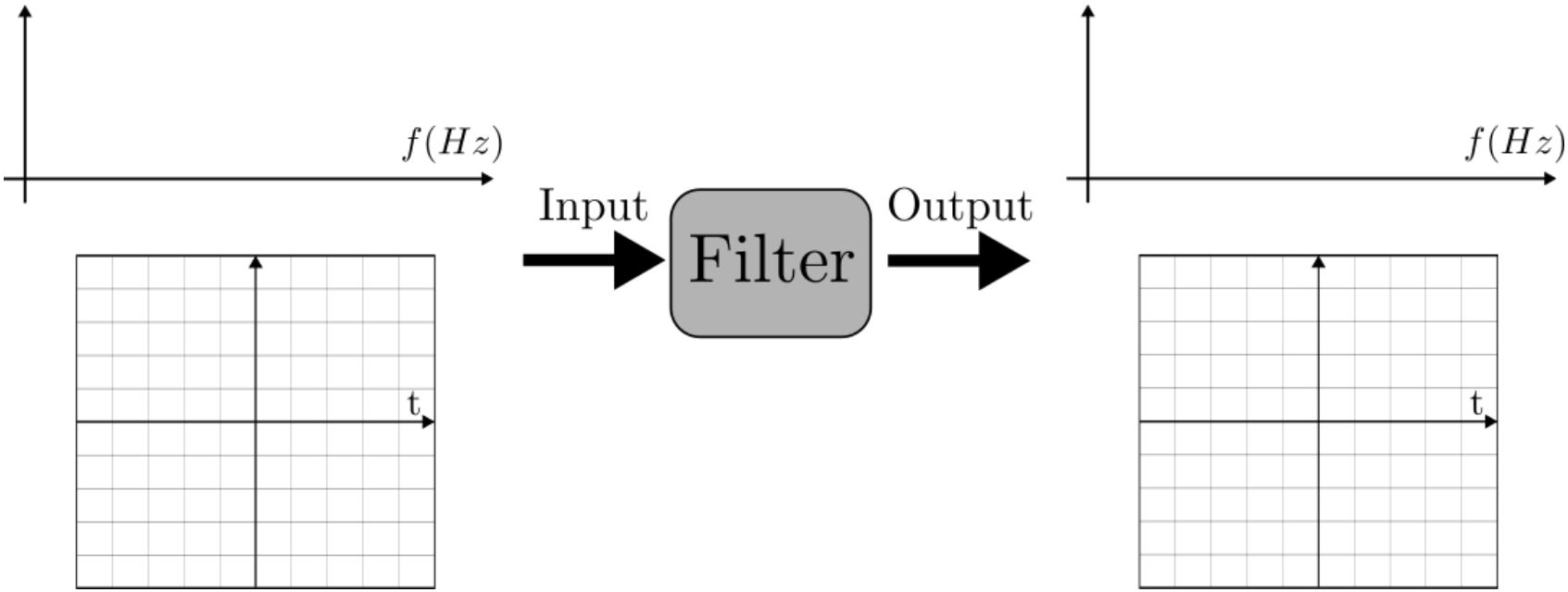






Filter Concept

A raw signal is input to a frequency filter and a filtered signal is output.



Filter Concept

So what is inside the *grey box*?

How does it work?

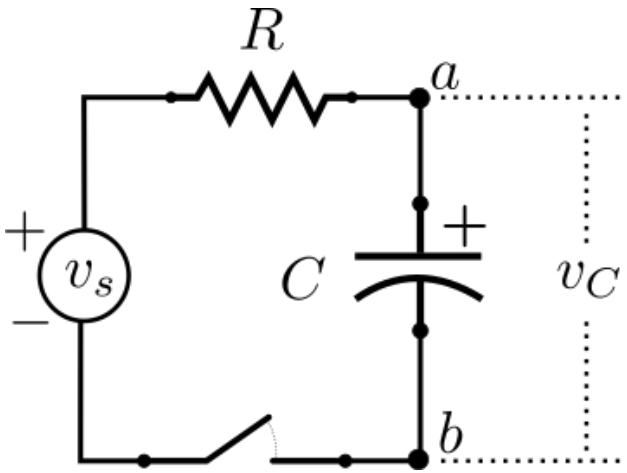
Interesting fact: The RC circuit used as first order filter is known as the Butterworth filter.

Filter Concept

Filters are constructed from time-varying circuits. The most basic of which is the RC filter.

First Order Model

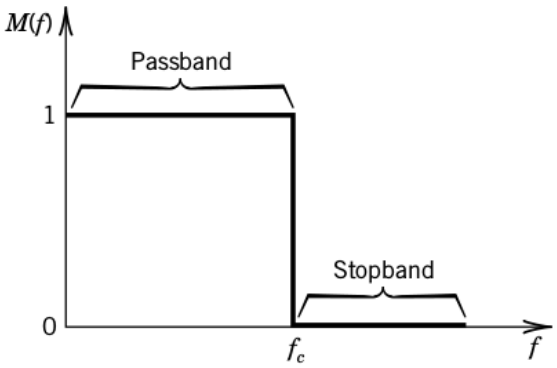
$$\tau\dot{y} + y = KA\sin(\omega t)$$



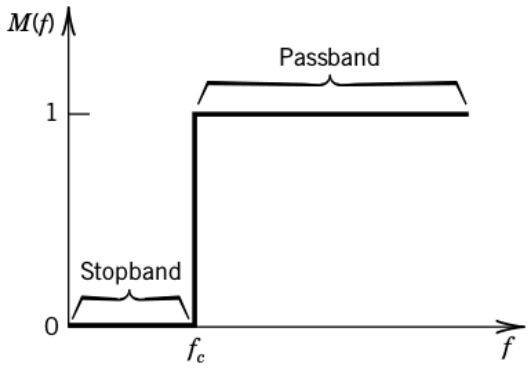
Response Equation

$$y(t) = Ce^{-\frac{t}{\tau}} + \frac{KA}{\sqrt{1+(\omega\tau)^2}}\sin(\omega t - \tan^{-1}(\omega\tau))$$

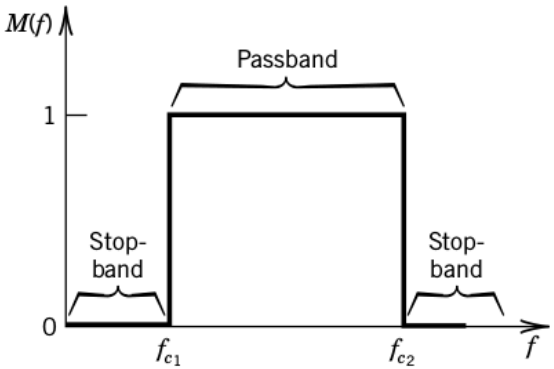
High-Pass, Low-Pass, and Band-Pass



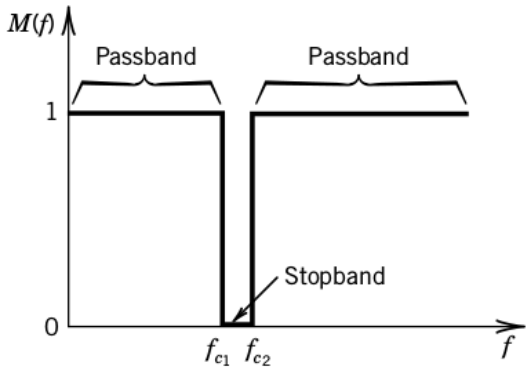
(a) Low-pass filter



(b) High-pass filter



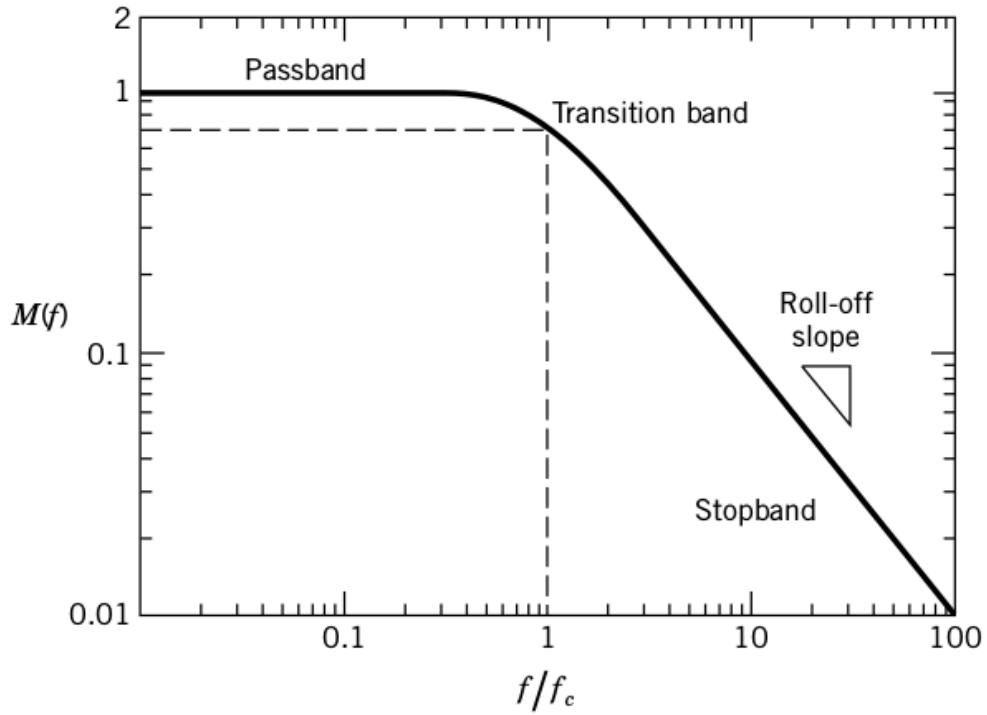
(c) Bandpass filter



(d) Notch filter

High-Pass, Low-Pass, and Band-Pass

Physical frequency filters do not behave in an ideal manner as the previous figure shows. The filter characteristics are frequency dependent.



Applications

Finally, what are filters used for?

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MATLAB Activity

Class Activity: Complete the activity as an individual. Discussion with your peers is encouraged.

Overview: Consider the parameterized square wave shown in figure 1 as the input voltage to a first order filter. The input to the system is the source voltage and the output is the voltage across the capacitor.

1. Sketch the expected response of the RC circuit on the axes provided BEFORE viewing the analyical solution.
2. Use the MATLAB code 'filters_activity.m' to view the analytical solution.
3. Do the expected results match the analytical results?
4. How does input frequency affect the output signal? In other words, what is shown as the input signal frequency is increased?
5. What could be changed in the filter circuit to reduce the affects of increasing input frequency?

Class Activity - continued